United States Patent [19]

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[11] **3,840,927**

[45] **Oct. 15, 1974**

[54] **SWIVEL UNIT FOR MOORING AND CARGO TRANSFER SYSTEM**

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[22] Filed: **Apr. 27, 1973**

[21] Appl. No.: **355,069**

[52] **U.S. Cl.** ..... **9/8 P,** 114/235

[51] **Int. Cl.** **B63b 21/52**

[58] **Field of Search** ..... 9/8 P; 285/134, 136; 114/230

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Attorney, Agent, or Firm—Lindenberg, Freilich, Wasserman, Rosen & Fernandez

[57] **ABSTRACT**

A mooring and cargo handling system of high reliability and low cost is provided, which includes a chain or other tension device connecting the buoy to a mooring base at the sea floor, and a swivel unit disposed along the tension device and having a lower section connected to undersea conduits and an upper section rotatably mounted on the lower section and connected to hoses that extend to the surface of the water. Both sections of the swivel unit are of annular shape so that the unit is hollow along its center, and the tension device extends along the center of the unit so that tension forces applied by the buoy are not transmitted through the rotatable joint of the two swivel unit sections.

6 Claims, 6 Drawing Figures

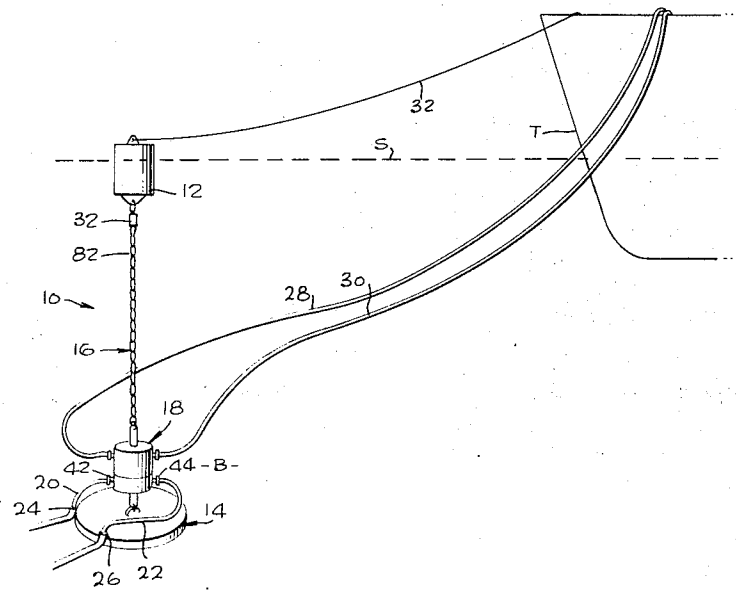


Fig. 1

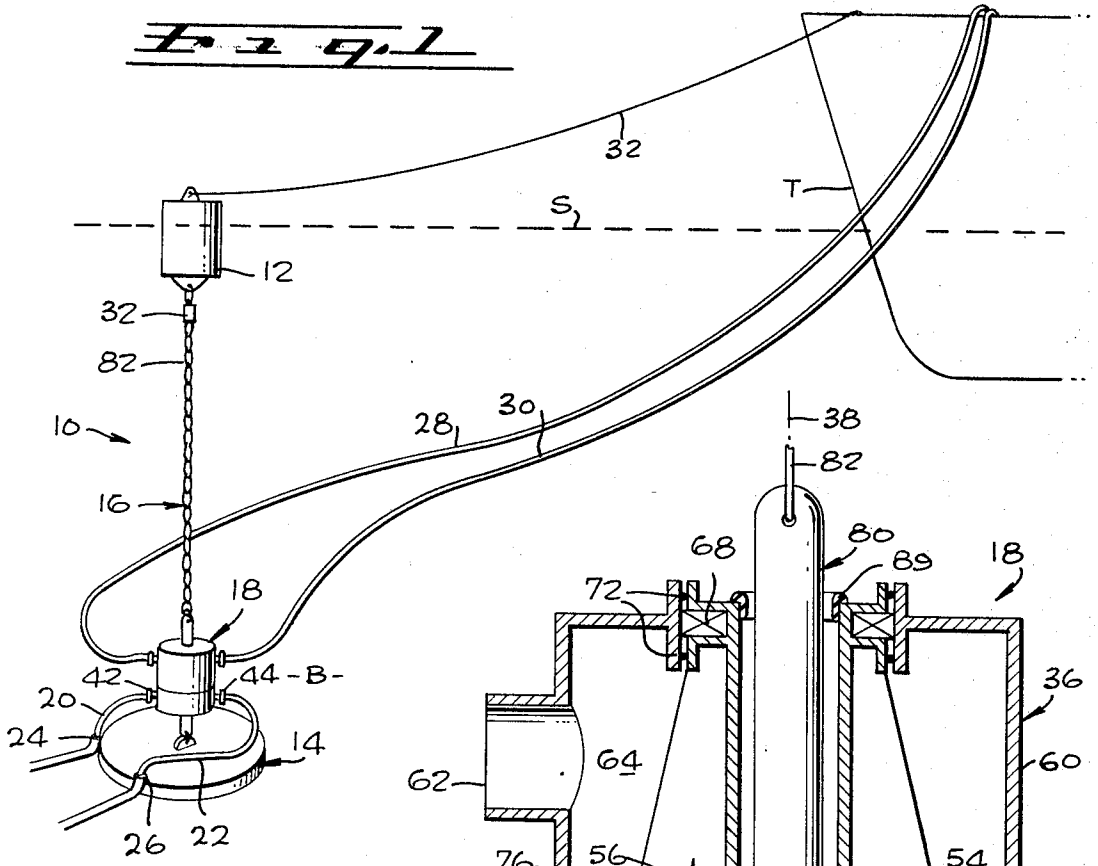
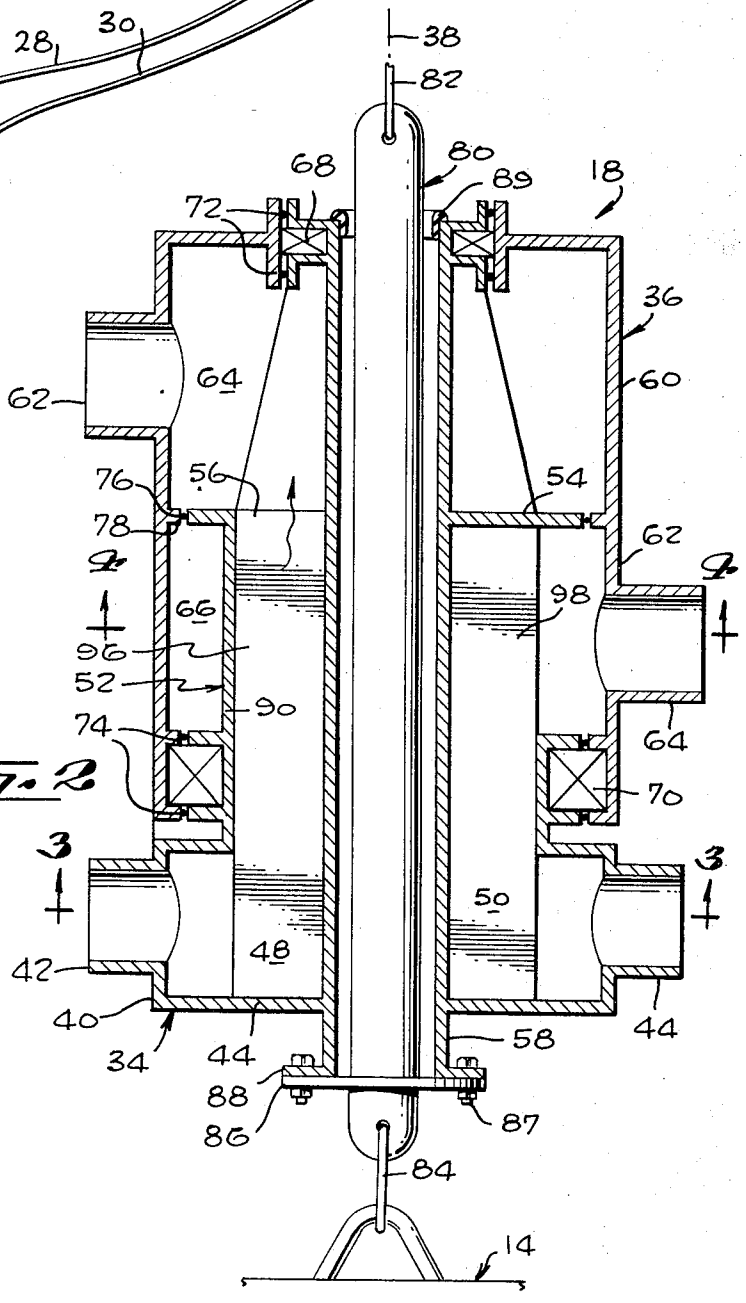

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Fig. 2


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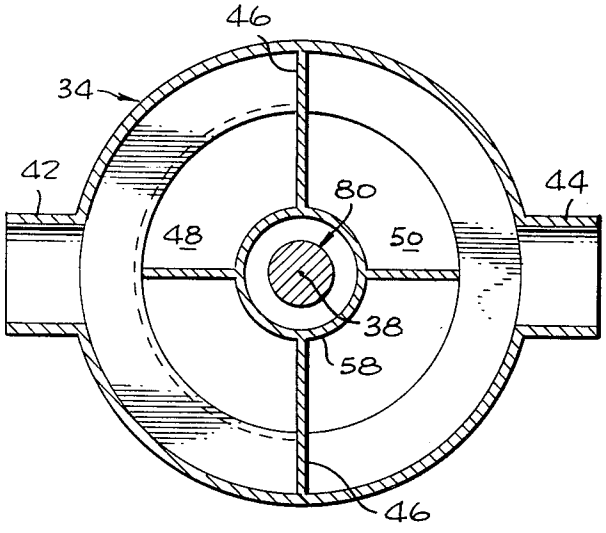


Fig. 3

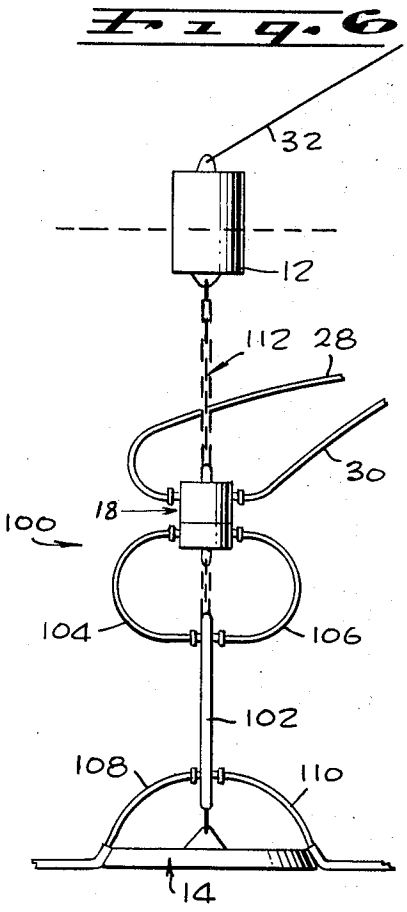


Fig. 6

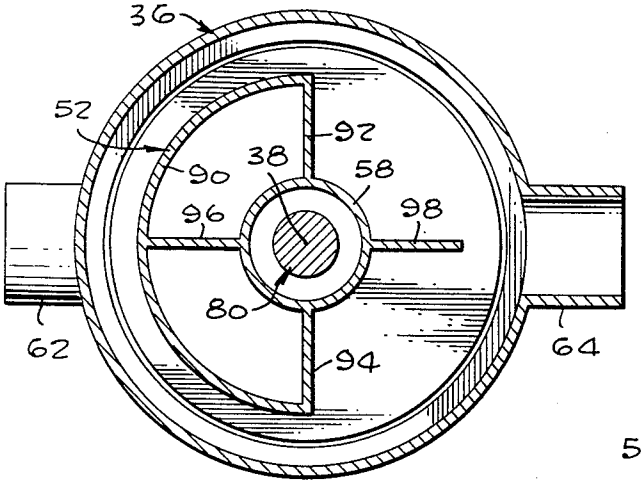


Fig. 4

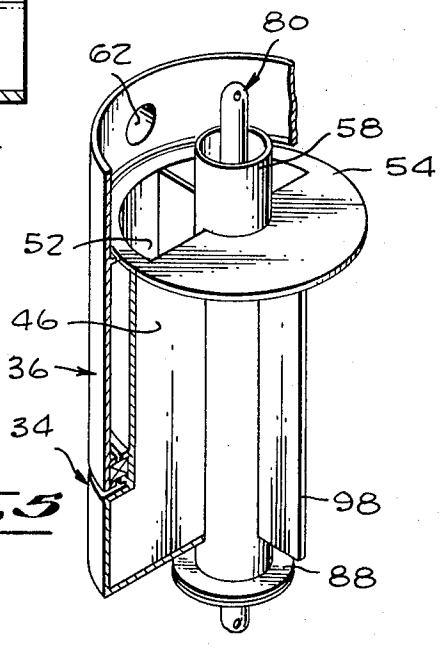


Fig. 5

SWIVEL UNIT FOR MOORING AND CARGO TRANSFER SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to mooring and cargo handling systems of the type wherein a buoy floating at the surface of the water is anchored to a mooring foundation at the bottom of the sea and conduits are provided to transfer oil or other cargo from conduits extending along the sea bottom to ships moored to the buoy.

Petroleum or other liquid cargo is often transferred to or from large tankers by mooring and cargo handling systems that lie in the sea and which are connected by pipe lines that run along the sea bottom to the shore or to a nearby receiving or distribution installation. The system includes an anchored buoy to which a ship can be moored, and one or more hoses that can extend to the ship. The system is normally constructed so that a ship which is moored to the buoy and connected to the cargo-transfer hoses, can move freely around the buoy. This permits cargo transfer to continue even while the ship moves under the influence of wind, waves, and current. The system can include a rotatable buoy from which a mooring cable and hoses extend for connection to the ship. The buoy is connected to a mooring foundation by way of a rotary fluid coupling through which the cargo moves. A massive coupling normally must be used to anchor the buoy in place without leaking the cargo, because mooring stresses may deform the coupling and allow leakage. Also, if the ship should exert an unusually high force on the buoy, the coupling is likely to be broken or deformed so that considerable leakage occurs. A mooring and cargo transfer system which eliminated the need for such a massive coupling while still permitting free movement of a loading or unloading ship about the buoy, would reduce the cost of the system and increase its reliability.

SUMMARY OF THE INVENTION

In accordance with one embodiment of the present invention, a mooring and cargo transfer system is provided which includes a rotatable fluid coupling and which also includes a tension device for anchoring the buoy to the mooring foundation without transferring tension forces through the connected parts of the fluid coupling. The fluid coupling or swivel unit includes lower and upper sections of annular shape that are rotatably connected and which are hollow along their axis of rotation. A tension device which connects the buoy to the mooring foundation includes a bar that extends through the hollow centers of the swivel unit sections and which is connected by chains to the buoy and mooring foundation.

One swivel unit is constructed to permit the transfer of two different cargoes without mixing them. The lower section of the swivel unit has a pair of nipples on opposite sides, a dividing wall that separates the regions connected to the different nipples, a duct extending upwardly from a first of the regions, and a top wall that seals the second region and that has an opening communicating with the duct. The upper swivel section has an enclosed upper portion lying above the upper wall and having a third nipple for receiving cargo that flows through the duct of the lower swivel section. The upper swivel section also has a lower portion that extends below the top wall and which has a fourth nipple for receiving cargo that has flowed into the second nipple.

The swivel unit maintains the two cargoes separate, while permitting rotation and permitting the tension device to pass through the unit without applying tension forces through it.

The novel features that are considered characteristic of the invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a mooring and cargo handling system constructed in accordance with an embodiment of the invention;

FIG. 2 is a sectional side view of the swivel unit of the system of FIG. 1;

FIG. 3 is a sectional view taken on the line 3—3 of FIG. 2;

FIG. 4 is a sectional view taken on the line 4—4 of FIG. 2;

FIG. 5 is a partial perspective and sectional view of the swivel unit of FIG. 2; and

FIG. 6 is a perspective view of a mooring and cargo transfer system constructed in accordance with another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a mooring and cargo transfer system **10** of the invention which includes a mooring buoy **12** that is highly buoyant for floating at the surface S of the sea, a base or mooring foundation **14** at the bottom B of the sea, and a tension apparatus **16** for connecting the buoy to the base to limit drifting of the buoy. The mooring foundation or base can be a single point type, as shown, or may by any of several other types such as a multiple leg type which employs several anchors spaced about a central location over which the buoy lies. The tension apparatus includes a long length of chain as well as hooks and other parts that can transfer a high tension load between the buoy and the base. A swivel unit **18** that is mounted along the tension apparatus, is connected to a pair of pipes or conduits **20, 22** that are held at **24** and **26** to the base and which extend along the bottom of the sea to a shore installation or to another sea installation. The swivel unit is also connected to a pair of hoses or conduits **28, 30** that extend upwardly to the surface S of the water and to a ship T. The ship is held to the system by mooring it with a mooring line **32** that attaches to the buoy **12.** After the ship is moored, connections are made to the hoses **28, 30** for cargo transfer through the hoses. Cargo such as petroleum may be transferred to the ship or may be received from the ship for transfer to a shore installation. The moored ship may move about the system, and both the buoy **12** and swivel unit **18** are designed to permit unlimited movement of the ship thereabout. To allow for such movement, a rotational coupling **32** is provided between the upper end of the tension apparatus **16** and the buoy **12** to permit free rotation of the buoy, while the swivel unit **18** is constructed so that the portion to which the hoses **28, 30** are connected can freely rotate with respect to the portion to which the lines **20, 22** are connected.

In accordance with the present invention, the swivel unit **18** is constructed so that the portion which carry rotatable seals do not carry any of the tension forces

that must be transmitted between the buoy 12 and base 14. As also illustrated in FIGS. 2–5, the swivel unit 18 includes a lower cargo-transfer section 34 and an upper cargo transfer section 36 that are rotatably connected to permit rotation about a vertical axis 38. Both sections 34, 36 are hollow along the axis 38 to permit extension of the tension device 16 therealong, so that none of the tension forces are carried by the two sections 34, 36.

The lower section 34 of the swivel unit includes an annular lower part 40 which has a pair of nipples or pipe couplings 42, 44 on opposite sides thereof that are connected to the two pipes 20, 22 that extend to the bottom of the sea. A lower wall 44 seals the bottom of the annular part 40. A vertical dividing wall 46 (FIG. 3) extends across the annular part 40 to divide it into two cargo receiving regions 48, 50 that are respectively coupled to the nipples 42, 44. The lower swivel unit section 34 also has a duct 52 coupled to the cargo region 48 and extending upwardly therefrom. An upper wall 54 lies at the upper end of the duct 52 and seals the area around the duct to enclose the area over the cargo region 50. The wall 54 has an opening 56 communicating with the inside of the duct 52. Accordingly, cargo flowing into the nipple 42 flows up through the duct 52 and through the opening 56 to an area above the upper wall 54. On the other hand, cargo flowing in through the second nipple 44 and into the region 50 is prevented from flowing higher than the upper wall 54. The lower cargo transfer section 34 also has a central pipe 58 that seals the hub portion of the swivel unit and which extends along the entire length of the unit.

The upper section 36 of the swivel unit includes an enclosed upper part or shroud 60 which lies above the upper wall 54 and which has a nipple 62 formed therein. The nipple 62 therefore leads to a region 64 which is in communication with the duct 52 so that cargo can flow between them. The upper swivel unit section 36 also has a lower part 62 which lies below the upper wall 54 and which has a nipple 64. The nipple 64 is in communication with the cargo region 50 that is connected to the nipple 44. The lower part 62 lies further from the axis 38 of the unit than the outermost wall of the duct 52, so that there is a space 66 between them that is filled with cargo from the region 50, and therefore even when the nipple 64 is rotated to a position near the duct 52, cargo from the region 50 can flow through nipple 64.

The swivel unit has two bearings 68, 70 where the lower and upper sections 34, 36 are rotatably connected. A pair of seals 72 are positioned on either side of the bearing 68 while another pair of seals 74 are positioned on either side of the bearing 70, to prevent or minimize the flow of seawater or cargo across the bearings. In addition, a rotatable seal 76 is provided between the end wall 54 and a location 78 on the upper section, to seal the region 64 above the end wall from the region below it.

The tension apparatus 16 includes a tension bar 80 which extends through the inside passageway of the pipe 58 of the swivel unit and along the axis 38 thereof. The upper end of the bar 80 is connected to the buoy through a chain 82, although a cable or other chain means can be used. The chain includes a rotatable joint 32 (FIG. 1) to permit rotation of the buoy. The lower end of the tension bar 80 is connected by a link 84 to an eyelet that is formed on the mooring base 14. The bar 80 carries all of the tension that is applied by the mooring buoy, and therefore serves as a tension bypassing device that transmits a tension load along the region occupied by the swivel unit 18 without transferring any of the tension force through the unit. The bar 80 has a flange 86 at its lower end which supports a flange 88 formed at the lower end of the pipe 58 of the swivel unit, so that the swivel unit is supported on the tension bar 80 to maintain its position therealong. The flanges 86, 88 are bolted together by bolts 87 to securely hold the swivel unit in place. A wear collar 89 minimizes wear of the tension bar on the pipe 58.

The swivel unit 80 is designed for construction using simple tube and plate shapes that are commonly available. Thus the duct 52 is formed by a plate 90 bent into a semi-cylindrical shape and by a pair of dividing wall plates 92, 94 that are welded to the ends of the curved plate 90 and to the central pipe 58. The plates 92, 94 are part of the dividing wall 46. Strengthening of the lower cargo transfer section is accomplished by the use of a pair of bracing plates 96, 98 that support the upper wall 54 on the lower wall 44 of the lower cargo transfer section, and which also strengthens the duct 52.

The use of a separate tension bar 80 to transmit tension forces of the buoy (and of the ship pulling on the buoy) greatly reduces distortion of the lower cargo transfer section 34. If, for example, the tension bar 80 were eliminated and the lower end of the pipe 58 were directly connected to the link 84 and the upper end connected to the chain 82, then the pipe 58 would be subject to large distortions. The pipe 58 could be made thick enough to withstand the tension of the buoy without actually breaking, but the distortions could result in leakage at the seals 74, 76, and especially 72. By securely connecting the tension bar 80 to the swivel unit 18 only at one end of the swivel unit, at the flanges 86, 88, tension loading of the swivel unit along its length and any resulting distortion is substantially eliminated. Another advantage of the separate tension device 80 is that it permits rapid replacement of the swivel unit in case of leakage or other malfunction. Removal is accomplished by removing the bolts 87 and disconnecting the bar 80 from the chain 82 to permit the swivel unit to be pulled up to the surface. The new swivel unit is installed in the reverse manner. A diver does not have to install any rotatable seals, or in fact not even a stationary fluid seal, so that replacement requires a minimum of diver time and reliability is high.

The swivel unit 18 can be positioned at many different locations along the tension device 16, and can be used in an orientation upside-down from that shown in FIG. 2. FIG. 6 illustrates a system 100 in which the swivel unit 18 is spaced a considerable distance above the mooring base 14. In this system, the conduits extending from the swivel unit 18 to the bottom of the sea include passageways within a tension pipe 102 that connects a pair of hoses 104, 106 leading to the swivel unit through a pair of hoses 108, 110 that extend to the sea bottom. The pipe 102 also serves as part of a tension device 112 that connects the buoy 12 to the mooring base 14. A pipe 102 can be utilized as both a cargo conduit and tension device without impairing reliability because there are no rotatable joints along the pipe 102 as there are along the swivel unit 18. The pipe 102 can be constructed with a pair of parallel passageways where it is desired to prevent mixing of the cargo in the two hoses 104, 106. The use of the pipe 102 enables the

swivel unit **18** to lie closer to the surface of the water without the need for flexible hoses to extend between the swivel unit and the sea bottom or the need for tying devices to prevent excessive movements of such hoses. The upper end of the pipe **102** can be connected directly to the lower section of the swivel unit **18** to eliminate the connecting hoses **104, 106,** and a secondary buoy can be used to urge the swivel unit and buoy upwardly.

Thus, the invention provides a mooring and cargo handling system of the type that permits free movement of a ship that is attached to the system by a hose and mooring line, which can be constructed at low cost and to operate reliably. This is accomplished by providing a swivel unit with rotatably connected sections through which the cargo moves, and by providing a tension device that bypasses the swivel unit in transferring tension between the buoy and the mooring base. The swivel unit can be constructed to be hollow along the axis of relative rotation of its sections, so that the tension device can extend along the axis. The swivel unit also permits the transfer of two separate cargoes without intermingling them, and yet permits the tension device to extend therethrough by utilizing dividing walls in the manner described earlier hereinabove. The unit can be modified to transfer only a single cargo, or to transfer more than two separate cargoes.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art and consequently it is intended that the claims be interpreted to cover such modifications and equivalents.

What is claimed is:

1. In a mooring and cargo handling system which includes a floating buoy to which ships can be tied, a mooring foundation on the sea floor to which the buoy can be secured, and a cargo conduit extending along the sea floor for carrying cargo between the ship and a shore installation or the like, the improvement comprising:

a cargo swivel unit having first and second swivel sections rotatably connected to each other to rotate about a vertical axis, said swivel sections being hollow along said axis;

first conduit means for coupling the first swivel section to the conduit that extends along the sea floor;

second conduit means for coupling the second swivel section to the ship; and

tension means connecting the buoy to the base and including a tension bypassing portion extending along the hollow region at said vertical axis between positions below and above the swivel unit to carry substantially the entire tension force applied by the buoy to the base, so that none of the tension force is transmitted through an appreciable length of either swivel section, said first swivel section being fixed to said tension bypassing portion to prevent relative sliding and relative rotation between them.

2. A mooring and cargo handling system comprising:

a base constructed to lie on a sea floor;

a mooring buoy constructed to float near the surface of the sea;

tension means extending between said base and said mooring buoy for anchoring the buoy to the base, said tension means including means for allowing rotation of the buoy with respect to the base;

a cargo swivel unit positioned along said tension means and coaxial therewith, said swivel unit having first and second swivel sections rotatably joined to each other about a substantially vertical axis of rotation to permit the transfer of cargo therebetween when the sections rotate with respect to each other, each of said sections being hollow along said axis of rotation to form a passageway therealong;

a first conduit extending downwardly from the first swivel section for carrying cargo that is flowing between the swivel unit and a conduit at the sea floor; and

a second conduit extending upwardly from the second swivel section for carrying cargo between the swivel unit and a ship that is moored to the buoy;

said tension means including a tension bypassing portion extending along said passageway between positions above and below the swivel unit to carry substantially the entire tension force applied by said buoy to the base so that substantially none of the tension force is transmitted through the rotatably joined swivel sections of the swivel unit.

3. The system described in claim **2** wherein:

said first swivel section is rotatably and slideably fixed at only its lower end to said tension bypassing portion;

said tension means includes a flexible chain means extending most of the distance between the buoy and base and having an upper end connected to the buoy; and

said tension bypassing portion includes a rigid member with an upper end connected to the lower end of the flexible chain means and a lower end connected to the base.

4. In a single point ship mooring and cargo transfer system, the improvement comprising:

a lower swivel section having an annular lower portion with first and second pipe couplings on opposite sides thereof, a lower wall sealing the bottom of the annular portion, a vertical dividing wall extending across the annular portion to divide it into first and second cargo regions respectively coupled to said first and second pipe couplings, a duct coupled to the top of said first cargo region and extending upwardly therefrom, and an upper wall at the upper end of said duct and having an opening in communication with the duct; and

an upper swivel section having an enclosed upper part above said upper wall and rotatably sealed thereto, said upper part having a third pipe coupling for carrying cargo that flows through the duct and first pipe coupling, and having a lower part surrounding and spaced outwardly from said duct and rotatably sealed to said annular lower portion, said lower part having a fourth pipe coupling for carrying cargo that flows through the second cargo region and the second pipe coupling.

5. The improvement described in claim **4** wherein:

said lower and upper swivel sections are hollow along their axis of rotation; and including

a buoy and base respectively above and below said swivel sections; and

a tension means extending through the hollow axial region of the swivel sections and connecting the buoy to the base.

6. In a mooring and cargo handling system which includes a floating buoy to which ships can be tied, a mooring foundation on the sea floor to which the buoy can be secured, and a cargo conduit extending along the sea floor for carrying cargo between the ship and a shore installation or the like, the improvement comprising:

a cargo swivel unit having first and second swivel sections rotatably connected to each other;

first conduit means for coupling the first swivel section to the conduit that extends along the sea floor;

second conduit means for coupling the second swivel section to the ship; and

tension means connecting the buoy to the base and including a tension bypassing portion extending between positions below and above the swivel unit to carry substantially the entire tension force applied by the buoy to the base, so that none of the tension force is transmitted through an appreciable length of either swivel section, said swivel unit being supported on said tension bypassing portion to fix the position of the unit along the tension means;

said first swivel section including a central pipe extending about the axis of the unit, walls defining first and second cargo receiving regions lying outside the lower end of the central pipe, an upper end wall extending around the central pipe and having an opening therein in communication with the first cargo region, a first pipe coupling connected to the first cargo region, the upper end of the second cargo region extending about the walls of the first cargo region at a location above the first pipe coupling;

said second swivel section including s shroud with a middle portion rotatably sealed to said end wall so that a lower end of the shroud surrounds the second cargo region and an upper end of the shroud encloses a region in communication with the first cargo region through the opening in the end wall, said shroud having a third pipe coupling in said lower end thereof communicating with said second cargo region and a fourth pipe coupling in said upper end thereof communicating with said first cargo region through the opening in the end wall.

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